IN REPLY REFER TO:

United States Department of the Interior

BUREAU OF LAND MANAGEMENT
SALT LAKE DISTRICT OFFICE
2370 South 2300 West
Salt Lake City, Utah 84119

3500
(U-027)

AUG 7 1990

Diane Neilson, Geologist
Director, Utah Div. of Oil, Gas, and Mining
355 West North Temple
3 Triad Center, Suite 350
Salt Lake City, Utah 84106

Dear Diane:

As per your recommendations and suggestions, the USGS has revised the study plan to address all potential causes of salt loss on the Salt Flats; however, the cost has increased from $459,000 to $1,290,700. This resulted in an effort, as per the enclosed letter, to reduce the cost somewhat without compromising the study. Also enclosed is a copy of the revised study plan which has been marked to reflect the District's recommended changes in scope to reduce costs. Please feel free to comment on the study plan at your earliest convenience.

The Salt Flats tour has been rescheduled for August 21, 1990, and will include visits to the Salt Flats north of I-80 and Reilly's facilities. We will meet at the Salt Lake District Office at 7:00 a.m. Transportation will be provided; please bring a lunch. Return will be around 6:00 p.m. Reilly has requested that the plant tour be limited to 10 people, so we will need to limit the number of non-committee members on the tour, or have two consecutive tours of Reilly's facilities. Please confirm your availability for the tour. It is requested that Stan Plaisier make arrangements for the tour of Reilly's facilities.

Enclosed is a copy of the approved charter. Mr. Zeller has selected Paul Anderson and Craig Forester as the Chair and Vice Chair respectively.

The District has formed a Conservation Coalition for the Salt Flats. The first meeting was held on July 31 and included representatives from the Governor, Senator Hansen, the Tooele County Commission, racer groups, and Reilly. The meeting covered a wide range of Salt Flats issues. The basic need for the study was affirmed. The coalition members are to provide comments by August 30.

8/7/90

The next Technical Review Committee meeting has been scheduled for August 24 at 9 a.m. at the Salt Lake District Office. Enclosed are minutes from the previous meetings. Topics to be discussed are as follows:

1. How useful is Pilot Valley as a control for the Salt Flats study? Are there enough similarities in the hydrology to make useful comparisons?

2. An exchange of potash lease rights from north of I-80 to Pilot Valley has been proposed. Is the enclosed report adequate to assess the potash resource in Pilot Valley? Reilly and the Racers have indicated that they will look into development feasibility. Enclosed is a letter from Trainum, Snowdon, Holland, Hyland, and Deane, attorneys for the racer interests, which discusses Pilot Valley.

3. A test salt replacement project has been proposed which would involve hauling salt from the Reilly facility to the Salt Flats. Should this be part of the USGS study or is enough known from previous successful small scale efforts to go forward with a project proposal? The committee should be prepared to discuss various locations and objectives for the project.

4. We have been looking into a separate study of wind erosion on the Salt Lake. Bill Wagner will present the study possibilities for discussion.

5. We will discuss the various possibilities for mitigating the salt loss. Please review Lines (1979) report concerning measures to resolve conflicts in the use of the Salt Flats.

Sincerely,

Deane H. Zeller

Deane H. Zeller
District Manager

Enclosures (6)
1-Cost Letter
2-Revised Study Plan
3-Approved Charter
4-Minutes
5-Report
6-Attorney's Letter

cc: Paul Summers, SC-325C
Ted Stephenson, U-942
Lee Case, USGS, WRD

8/7/90

BRINE SUPPLY AND RESERVES
NORTHWEST BONNEVILLE AREA

by

M. P. Nackowski

Registered Geological Engineer

January 15, 1967
Salt Lake City, Utah

Prepared for

Quintana Petroleum Corporation

Houston, Texas

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SUMMARY

During the months of June and July, 1966, 42 auger holes, each from 12 to 16 feet deep, were drilled in the Northwest Bonneville brine area to determine the brine supply and reserves. Auger holes were drilled to approximate a 2-mile grid. Brine from each hole was analyzed for Na, K, Li, Mg, Ca, SO_4, and Cl. The brine specific gravity was measured and the water table was noted for each hole. The lithology of the sediment at one-foot intervals was described. For selected sediment samples, the sediment specific gravity was determined.

The Northwest Bonneville area located about 15 miles north of the Bonneville Potash works of the Kaiser Chemical Company at Wendover, Utah is a former cove of Lake Bonneville, is pear shaped, nearly 20 miles long in a northeasterly direction and approximately 8 miles wide. It comprises some 140 square miles and is part of the Great Salt Lake Desert, a dry saline remnant of the larger Lake Bonneville. Sediments in the Great Salt Lake Desert salt flat include sand, silt, and clay which are saturated with brine below the water table.

The brine supply, grade, and tonnage are weighted averages which were calculated using a polygonal modified contour method. This grade in percent in Blocks A through G is 0.614 KCl, 11.56 NaCl, 0.518 $MgCl_2$, and 0.0172 LiCl. The brine supply for the Northwest Bonneville area approximates 174.3 billion gallons which contains about 5.1 million tons of KCl for 10 vertical feet of brine saturated sediment.

The brine reserve includes only the brine with a potash content greater than 0.50 percent KCl. For Blocks A, B, and C, the brine reserves total approximately 42.3 million tons and contain 475,910 tons KCl. An additional 16.7 million tons of brine which contain 110,190 tons of KCl are included in Block D.

The depletion rate and life of the property are calculated for an annual production of approximately 25,000 tons KCl during a 100-day production period. Brine production from Blocks A, B, and C can be projected for a life of 16 years during which time 400,000 tons of KCl will be produced. The brine grade will decrease from nearly 1.13 percent KCl to 0.50 percent KCl and the quantity of brine required to maintain an annual production of 25,000 tons of KCl increases from about 500 million gallons to over 1 billion gallons. The addition of Block D within the production area will extend the life of the property to 17 years.

I. INTRODUCTION

During the months of June and July, 1966, 42 auger holes, each from 12 to 16 feet deep, were drilled within the Northwest Bonneville brine area and in the Bonneville brine area to determine the brine supply and reserves which were estimated in a preliminary report submitted by M. P. Nackowski in February, 1966[8].

A brine sample from each hole was analyzed for Na, K, Li, Mg, Ca, SO_4, and Cl and the brine specific gravity was measured. The water table was noted for each hole. The lithology of the sediment encountered at successive one-foot intervals was described and the moisture content was determined. For selected sediment samples, the sediment specific gravity was also determined.

From these data the total brine supply and the brine reserves are calculated for the Northwest Bonneville brine area. The depletion rate and production life are also calculated for a selected production schedule and cutoff grade.

II. GEOLOGIC ENVIRONMENT, NORTHWEST BONNEVILLE AREA

The Northwest Bonneville area is part of the Great Salt Lake Desert which is a dry, saline remnant of the larger, former fresh water body that was named Lake Bonneville by Gilbert[6]. The Northwest Bonneville area was a cove of Lake Bonneville and opened northeastward into Lake Bonneville. The area is underlain by lake sediments and includes approximately 140 square miles. The Great Salt Lake Desert, which is shown in Figure 1 found at the end of the report, from Nolan[11] is about 150 miles long in a north-south direction and extends from Callao on the south northward 11 miles beyond Newfoundland on the Southern Pacific Railroad line. It is about 40 miles wide in an east-west direction and extends eastward from Wendover to Knolls. In area, the Great Salt Lake Desert comprises about 3,000 square miles. Lake Bonneville was considerably larger. It extended 300 miles north-south and 180 miles east-west. Its surface area approximated 20,000 square miles.

At their highest level, Lake Bonneville waters extended 1,000 feet above the present desert surface. Former Lake

Bonneville discharged northward into the Snake River. When outflow ceased, the water level receded to its present level in Great Salt Lake. The remnant lake also became progressively saline as evaporation proceeded. The Great Salt Lake Desert part of Lake Bonneville is separated now from the restricted Great Salt Lake basin by a threshold of sediments which rises about 10 feet above the present level of the desert between the Terrace and Lakeside Mountains.

The sediments in the Great Salt Lake Desert salt flat comprise basal and marginal alluvial gravels derived from surrounding mountains and superimposed layers of lake sediments which include thin bedded oolitic and fecal pellet sand, silt, and clay. Mineralogically the lake sediments include precipitated calcium carbonate and gypsum, detrital quartz, and clay minerals.

In the vicinity of the Bonneville Potash Plant, near Wendover, the lake sediments are overlain by a crystalline layer of halite which ranges in thickness from three feet to a feather edge. In the Northwest Bonneville area, the crystalline salt as depicted by Nolan[(11)] is a layer of loose, granular halite and gypsum mixed with lake sediment.

This layer ranges from 1 foot thick to a feather edge.

The layered lake sediments are slightly permeable[1,2] and are saturated with brine below the water table. Brine will flow through them and drain from them under a gravity head. The effective permeability of the lake sediments depends mostly upon vertical, closely spaced columnar contraction joints in clay layers which act as pipe-like channels. The effective permeability also depends upon bedding plane discontinuities which act as extensive horizontal planar channels, and on intersticies or intergranular openings in the clastic lake sediments. The interstitial permeability is most effective in the oolitic sand layers and least effective in the clay-sized lake sediment layers.

The ground water brine, which occurs in the lake sediments and saturates the sediment from the water table downward, is more saline below the areas underlain by a salt crust. The salinity decreases laterally away from the crystalline salt crust.

The surface of the Northwest Bonneville Area is nearly flat and smooth and is pictured in photograph 4 of Figure 2, page 8. The surface is slightly convex, however. This is reflected by distance of the water table below the surface.

Within the central area the water table is from one to two feet below the surface. The depth to the water table increases toward the periphery of the basin. Where the cove opens into the desert, the surface is hummocky and irregular. It is covered with sand dunes which range up to 4 feet tall. The hummocky surface is pictured in photographs 1, 3, and 6 of Figure 2, pages 7 and 8.

III. EXPLORATION PROGRAM

During the months of June and July, 1966, exploration auger holes were drilled within the Northwest Bonneville brine area and in the Bonneville brine area to establish the brine reserves which were estimated in a preliminary report from data compiled by Nolan. A total of 42 auger holes each from 12 to 16 feet deep was drilled. The lithology of the lake sediment encountered at successive one-foot intervals was described and a composite brine sample was collected from each hole except No. 41.

Auger test holes were drilled as nearly as possible at section corners on a 2-mile grid. The location of the auger holes is shown on the maps of Figures 3, 4, and 5 found at the end of the report. Only 35 holes were drilled within the Northwest Bonneville area. Seven holes were drilled at 2-mile intervals outside the area in an easterly direction to establish the brine grade in this contiguous area.

The holes were drilled with a portable gasoline powered post hole auger 6" diameter, which was suspended by a cable from an 18-foot "A" frame mounted on a snow cat. Threaded, coupled, 2-inch diameter pipe, each 2 feet long, was used as sectional drill pipe. Holes were drilled in one-foot increments, and relatively undisturbed sediment samples were removed at each one-foot interval from the auger spiral.

The equipment and augering sequence are depicted in the six photographs of Figure 2, pages 7 and 8. The drill crew consisted of five persons, the snow cat and winch operator, one driller, one driller helper, one Geological Engineer, and one field secretary.

The sediment was described lithologically at the test site by the Geological Engineer as it was removed from the auger. A sample from each run was sealed in a plastic bag for laboratory analysis, and the lithologic description was

1. Collaring auger hole.

2. Sediment from single run.

3. Removing and describing sediment.

Figure 2. Photographs of Exploration Augering Sequence

4. Recording sediment description.

5. Collecting brine sample.

6. Preparation for move to next location.

Figure 2. Photographs of Exploration Augering Sequence

recorded by the field secretary.

From each test hole a composite brine sample for chemical analysis was recovered in a one-quart plastic bottle which was adequately labelled and securely capped.

IV. PRESENTATION OF DATA

The assembled field and laboratory data are presented in appendicies and on appropriate maps. These data include lithologic logs, moisture content, and specific gravity of sediments. Chemical analyses of brine from each auger hole are listed as are the brine specific gravities. Brine grade calculations of average brine specific gravity, specific gravity of brine saturated sediment, and brine supply are also appended. Auger hole locations and land holdings are shown on appropriate maps.

Appendix I contains lithologic logs and moisture (H_2O) content of sediment encountered in the exploration auger holes. These logs are prefixed by an explanation of the grade scale terms used in describing the sediment. All field descriptions are megascopic. The moisture contents represent weight percent water in the original undried sample. All samples were dried in thermostatically controlled ovens for 12 hours at 110^{o} centigrade.

The chemical analyses and the specific gravity of the brine are contained in Appendix II. These data recalculated to weight percent are also tabulated for the products KCl, NaCl, $MgCl_2$, and LiCl.

In Appendix III the brine grade weighted average calculations are tabulated. Four methods of calculations were used for comparison and include the polygonal modified contour method, the polygonal method, the contour method, and the arithmetic average.

In Appendix IV the weighted and average brine specific gravities are calculated. Four methods are shown. They include the polygonal modified contour method, the polygonal method, the contour method, and the arithmetic average.

Appendix V tabulates calculations of weighted average and mathematical average specific gravity of brine saturated sediment.

In Appendix VI are tabulated brine supply calculations. The brine supply is presented in the units pounds of brine per cubic foot. These units are converted to gallons and tons of brine per square mile of area per vertical linear foot in the body of the report.

The auger holes are located on maps labelled Figures 3, 4, and 5. Partial mineral land holdings, exploration permits, and production leases of several principals are shown on Figure 3. On Figure 4, Northwest Bonneville Area Brine Reserves map, are shown auger hole locations, and brine grade contour blocks. On Figure 5 found at the end of the report, are shown the polygons outlining the area of influence of each auger hole for polygonal weighted average calculations.

V. THE BRINE SUPPLY

The brine supply includes the total interstitial ground water brine which occurs below the water table in the sand, silt, and clay sediment within the Northwest Bonneville area.

The brine supply, the grade, and tonnage are weighted averages which were calculated using a polygonal modified contour method. The area was divided into concentric strips by iso-potash contours. These strips are designated as blocks A through G and are shown on Figure 4 at the end of the report. The weighted average grade of the brine in each block and for the entire brine supply are listed on Table 1, page 13. The weighted average grade in percent of the total brine supply based on a polygonal modified contour calculation in blocks A through G is 0.614 KCl, 11.56 NaCl, 0.518 $MgCl_2$, and 0.0172 LiCl. Brine grade calculations are appended.

The quantity of the brine supply for 10 vertical feet of saturated sediment is calculated as gallons of brine, tons of brine, and tons of the commodities KCl and NaCl. These quantities are summarized on Table II, page 14. Brine supply calculations are appended.

The total brine supply for the Northwest Bonneville area approximated 174.3 billion gallons which contains about 5.1 million tons of KCl for 10 vertical feet of brine saturated sediment.

Table I

BRINE GRADE NORTHWEST BONNEVILLE AREA,
POLYGONAL MODIFIED CONTOUR METHOD

Weight Per Cent

Area Block	Size Sq. Mi.	KCl	NaCl	$MgCl_2$	LiCl
A	13.32	1.342	20.84	1.144	0.0345
B	16.31	1.181	20.82	0.963	0.0323
C	16.89	0.906	17.92	0.862	0.0252
Sub Total A,B,C Average Grade @ 0.75% KCl Cutoff	46.52	1.127	19.78	0.978	0.0304
D	18.28	0.659	13.75	0.504	0.0182
Sub Tot. A,B,C,D Average Grade @ 0.50% KCl Cutoff	64.80	0.995	18.07	0.844	0.0269
E	28.54	0.387	8.18	0.298	0.0116
F	25.05	0.230	5.10	0.201	0.0074
G	21.23	0.211	3.86	0.191	0.0066
Total	139.62	0.614	11.56	0.518	0.0172

Table II

BRINE SUPPLY NORTHWEST BONNEVILLE AREA

(10-Foot Vertical Interval Saturated Sediment)

Area Block	Size Sq. Mi.	Gallons Brine	Tons Brine	Tons KCl	Tons NaCl
A	13.32	16,500,245,760	81,156,420	1,089,119	16,912,998
B	16.31	20,340,129,540	99,214,820	1,171,727	20,656,526
C	16.89	22,049,768,380	105,379,850	954,741	18,884,069
Sub Total (A,B,C)	46.52	58,890,143,680	285,751,090	3,215,587	56,452,593
D	18.28	23,216,322,820	112,982,120	744,552	15,535,042
Sub Total (A,B,C,D)	64.80	82,106,466,500	398,733,210	3,960,139	71,987,635
E	28.54	35,294,615,590	163,864,020	634,154	13,404,077
F	25.05	31,866,727,390	138,623,250	318,833	7,069,786
G	21.23	25,059,108,450	108,428,460	228,784	4,185,339
Total	139.62	174,326,917,930	809,648,940	5,141,910	96,647,837

VI. BRINE RESERVES

The brine reserves include only the brine which can be produced by draining under a gravity head into production canals. Also only the brine with a potash content greater than 0.50 percent KCl, which is the selected cutoff grade, is included in the brine reserves calculations.

The brine reserves are limited by the specific yield, the percentage of brine contained in the brine saturated sediment which will drain from the saturated sediment. The calculated average specific yield is 14.8 percent. This is the ratio of the average moisture content of sediment above the water table and below the water table. The average moisture content of sediment above and below the water table for each hole is presented for combined lithologies and separately for silt, clay, and sand on Table III, page 16. The brine reserves are also limited by the cutoff grade which has been arbitrarily selected as 0.50 percent KCl. The cutoff grade is that grade of brine whose unit market value equals unit operating costs. The brine reserves are summarized on Table IV, page 17. For Blocks A, B, and C, the brine reserves total

Table III

AVERAGE MOISTURE CONTENT NORTHWEST BONNEVILLE AREA

Brine Exploration Auger Holes, Weight Per Cent Water

	Sediment Above Water Table				Sediment Below Water Table			
Hole	Clay	Silt	Sand	Composite	Clay	Silt	Sand	Composite
1	27.4	--	--	27.4	31.8	33.8	--	32.3
2	25.7	34.3	--	29.1	33.8	32.4	32.9	32.9
3	--	26.7	20.0	22.2	29.6	36.8	32.1	34.6
4	--	40.7	36.6	39.1	40.1	44.4	--	41.9
5	37.7	25.5	--	33.6	35.9	47.0	--	38.7
6	31.6	--	--	30.3	34.6	--	--	34.6
7	25.3	26.3	--	25.3	37.6	36.4	24.9	34.7
8	--	25.5	--	25.5	35.5	--	35.2	35.4
9	--	28.4	25.7	27.1	33.9	35.6	--	34.4
10	--	29.3	--	29.3	32.1	40.6	41.9	38.4
11	28.8	26.2	26.1	27.2	--	45.4	23.8	28.1
12	32.9	31.2	21.2	30.5	32.3	34.9	23.0	28.3
13	29.9	31.7	33.9	31.8	34.7	37.9	39.1	38.0
14	--	36.0	17.9	26.0	--	32.8	22.8	24.4
15	33.8	29.8	--	30.8	37.4	--	19.1	22.8
16	32.7	29.7	28.2	29.7	38.5	41.6	31.2	35.3
17	30.8	24.4	19.7	23.9	--	22.4	22.0	22.1
18	45.0	35.5	24.2	32.0	--	30.4	26.2	28.3
19	31.1	--	--	31.1	35.5	34.1	37.6	35.3
20	--	25.0	29.1	25.8	38.8	33.9	--	38.4
21	--	25.0	25.5	25.3	31.5	30.3	--	30.4
22	--	--	24.2	24.2	--	29.8	34.1	30.1
23	--	26.7	27.5	26.9	--	33.6	33.8	33.7
24	32.9	29.7	--	34.1	39.2	32.3	34.5	34.2
25	--	27.4	26.3	26.9	--	31.7	30.8	31.4
26	--	--	26.2	26.2	34.4	36.6	28.6	33.9
27	--	27.2	27.3	23.9	36.1	39.5	28.0	36.0
28	--	27.4	24.1	25.2	32.5	36.2	33.0	34.9
29	--	--	24.5	24.5	--	33.4	32.3	33.0
30	--	27.2	28.9	28.3	--	38.4	34.2	37.8
31	--	34.3	30.2	33.5	--	50.6	43.5	45.6
32	--	--	28.4	28.4	--	31.7	31.8	31.7
33	--	34.0	30.4	32.4	--	43.4	36.6	38.6
34	--	33.9	39.8	36.4	--	--	41.9	41.9
35	--	--	28.2	28.2	--	25.5	24.3	24.4
Totals	445.6	799.0	674.1	1002.1	735.8	1113.4	879.2	1176.5
Average	31.83	29.59	26.96	28.63	35.04	35.92	31.40	33.61

Table IV

BRINE RESERVES NORTHWEST BONNEVILLE AREA

Specific Yield 14.8 Wt. Per Cent of Brine Supply from 10-Foot Vertical Interval Saturated Sediment

Area Block	Size Sq. Mi.	Gallons Brine	Tons Brine	Tons KCl	Tons NaCl
A	13.32	2,442,036,370	12,011,150	161,190	2,503,120
B	16.31	3,010,339,170	14,683,790	173,420	3,057,170
C	16.89	3,263,365,720	15,596,220	141,300	2,794,840
Sub Total Reserves @ 0.75% KCl Cutoff		8,715,741,260	42,291,160	475,910	8,355,130
D	18.28	3,412,799,450	16,721,350	110,190	2,299,190
Sub Total Reserves @ 0.50% KCl Cutoff		12,128,540,710	59,012,510	586,100	10,654,320
E	28.54	5,223,603,110	24,251,870	93,850	1,983,800
F	25.05	4,716,275,650	20,516,240	47,190	1,046,330
G	21.23	3,708,748,050	16,047,410	33,860	619,430
Total Reserves @ 0.10% KCl Cutoff	139.62	25,777,167,520	119,828,030	761,000	14,303,880

approximately 42.3 million tons and contain 475,910 tons KCl. An additional 16.7 million tons of brine which contain 110,190 tons of KCl are contained in the peripheral Block D.

More than 60 million tons of brine and 170,000 tons of KCl are available in Blocks E, F, and G but at a grade between 0.50 to 0.10 percent KCl.

VII. ANNUAL BRINE PRODUCTION CAPACITY DEPLETION RATE AND LIFE OF PROPERTY

The annual brine production capacity is limited by several variables including the brine reserves and the quantity of brine which will drain from the sediment into production canals during the effective evaporation season that approaches 100 days. The brine reserves represent the maximum brine that can drain from the sediment, and are limited by the specific yield which is 14.8 percent of the moisture content of the saturated sediment. These brine reserves total 586,100 tons KCl for Blocks A, B, C, and D. The annual production capacity is approximately 25,000 tons KCl. This is based on a physical and mathematical analogy with the production history of the Bonneville Potash operation first made in the preliminary report[8]. Based on this analogy, the annual specific yield for a 100-day production season may approximate 30,000 tons of KCl or about 1/20 of the brine reserve tonnage.

For an annual production of 25,000 tons KCl, the depletion rate and the life of the property are calculated for a model which approximately represents one limiting case of mechanics of brine recharge and depletion. This model assumes that the brine production area is recharged by rainfall, and snow during the year following the 100-day production period. It also assumes no lateral or vertical upward migration of brine to re-establish the water table and refill the drawdown cone within the production area. The model further assumes that the available potash and other salts occur only in the brine reserves and no quantities adsorbed on clay surfaces in excess of the specific yield will be recovered. The model is based on a cutoff grade of 0.50 percent KCl and assumes that production canals will extend across Blocks A, B, and C.

The annual production and the depletion rate are calculated for 15-foot deep production canals and an effective drawdown of 10 vertical feet. Production is presented as tons of KCl annually. The annual average grade as percent KCl is also presented for each year. These data are summarized on Table V, page 21, for an active production area including Blocks A, B, and C.

A life of 16 years is projected during which time 400,000 tons of KCl will be produced. As the grade of the brine decreases from nearly 1.13 percent KCl to 0.50 percent KCl, the quantity of brine required to maintain a constant annual production of 25,000 tons KCl increases from nearly 500 million gallons to more than 1 billion gallons.

The depletion rate and life are summarized in Table VI, page 22, for an active production area including Blocks A, B, C, and D. One year is added to the life expectancy when Block D is included within the active production area. The life extends to 17 years, but the terminal year brine grade is 0.495 percent KCl.

A more favorable model assumes that the production area is recharged annually not only by precipitation, but by lateral horizontal, and vertical upward migration of

Table V

DEPLETION AND LIFE NORTHWEST BONNEVILLE AREA
PRODUCTION BLOCKS A, B, & C

(Annual Production 25,000 Tons KCl. Cutoff Grade 0.50% KCl)

Year Life	Brine Grade % KCl	Brine		Cumulative Production	
		Sp. Gr.	Gallons	Gallons Brine	Tons KCl
1	1.127	1.1642	456,853,542	456,853,542	25,000
2	1.068	1.1556	485,684,969	942,538,511	50,000
3	1.012	1.1474	516,182,720	1,458,721,231	75,000
4	0.959	1.1397	548,425,213	2,007,146,444	100,000
5	0.909	1.1324	582,322,897	2,589,469,341	125,000
6	0.861	1.1254	618,633,805	3,208,103,146	150,000
7	0.816	1.1188	656,531,503	3,864,634,649	175,000
8	0.773	1.1126	696,899,568	4,561,534,217	200,000
9	0.731	1.1067	740,938,983	5,302,473,200	225,000
10	0.693	1.1011	785,438,891	6,087,912,091	250,000
11	0.651	1.0958	832,649,148	6,920,561,239	275,000
12	0.622	1.0908	883,386,867	7,803,948,106	300,000
13	0.589	1.0860	937,173,639	8,741.121,745	325,000
14	0.558	1.0815	993,165,159	9,734,286,904	350,000
15	0.529	1.0772	1,051,816,647	10,786,103,551	375,000
16	0.501	1.0731	1,114,831,590	11,900,935,141	400,000
Total 16			11,900,935,141	11,900,935,141	400,000

Table VI

DEPLETION AND LIFE NORTHWEST BONNEVILLE AREA
PRODUCTION BLOCKS A, B, C, & D

(Annual Production 25,000 Tons KCl. Cutoff Grade 0.50% KCl)

Year Life	Brine Grade % KCl	Brine Sp. Gr.	Brine Gallons	Cumulative Production Gallons Brine	Cumulative Production Tons KCl
1	0.995	1.1513	523,259,651	523,259,651	25,000
2	0.953	1.1448	549,391,890	1,072,651,541	50,000
3	0.912	1.1386	577,200,611	1,649,852,152	75,000
4	0.873	1.1327	606,200,971	2,256,053,123	100,000
5	0.836	1.1270	636,206,833	2,892,259,956	125,000
6	0.799	1.1216	668,859,079	3,561,119,035	150,000
7	0.765	1.1164	701,869,012	4,262,988,047	175,000
8	0.732	1.1114	736,851,851	4,999,839,898	200,000
9	0.701	1.1066	772,780,990	5,772,620,888	225,000
10	0.671	1.1021	810,457,198	6,583,078,086	250,000
11	0.642	1.0977	850,639,066	7,433,717,152	275,000
12	0.615	1.0935	891,387,029	8,325,104,181	300,000
13	0.589	1.0895	934,130,863	9,259,235,044	325,000
14	0.564	1.0857	978,869,399	10,238,104,443	350,000
15	0.540	1.0820	1,025,852,989	11,263,957,432	375,000
16	0.517	1.0785	1,075,096,287	12,339,053,719	400,000
17	0.495	1.0752	1,126,245,106	13,465,298,825	425,000
Total 17			13,465,298,825	13,465,298,825	425,000

brine to re-establish an equilibrium horizontal water table following the 100 days' production season It further assumes a homogeneous sediment environment so that horizontal and vertical permeabilities of the sediments are equal and that the vertical and horizontal brine contributions are proportional to the horizontal and vertical areas contributing brine. The model also assumes that the salt content of the brine contributed from below is the same grade as that in the production area and that the salt content of the brine contributed laterally is the weighted average grade of the peripheral brine.

The depletion rate possibly will be influenced by diffusion mixing of brine which will not drain from the sediment with water and brine which replaces the brine withdrawn annually. Diffusion mixing will decrease the depletion rate and increase the life expectancy. The actual recharge characteristics, depletion rate, and life of the property will probably most nearly approximate that for which calculations have been made.

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APPENDIX I

LITHOLOGIC LOGS AND MOISTURE CONTENT OF NORTHWEST BONNEVILLE EXPLORATION HOLES

Explanation of Lithologic Descriptions

Grade Scale

(Wentworth, 1922)

Grade Scale Limits mm.	Grade Scale Terms
2	
	Very Coarse Sand
1	
	Coarse Sand
½	
	Sand
¼	
	Fine Sand
1/8	
	Very Fine Sand
1/16	
	Silt
1/256	
	Clay

Standard for Combining Grade Scale Terms

Sand	=	medium, fine, or very fine grained sand
Coarse sand	=	very coarse or coarse grained sand
Sandy silt	=	less than 20 percent sand
Sandy clay	=	less than 20 percent sand
Silty clay	=	less than 20 percent silt

Any description with two names such as Sand-Silt is composed of about 50 percent of each material.

Hole No. NWB-1 | Date Drilled: 6/27/66

Location: | Sampler: M. P. N. & U. J.

Depth Feet	Lithologic Description	Sediment Spec. Grav.	Moisture (Wt. Percent Water)
0-1	Silty clay, light gray tan		26.5
1-2	Silty clay, light gray tan		29.6
2-3	Silty clay, light gray tan		26.7
3-4	Silty clay, medium gray tan, limonite spots		28.0
4-5	Silty clay, medium gray to dark gray		26.4
	Water Table		
5-6	Silty clay, dark gray, medium gray to green gray		28.6
6-7	Silty clay, dark gray, medium brown silt		30.6
7-8	Silt, thin bedded ¼" layers medium gray-dark gray		33.8
*			
14-15	Silty clay, medium gray		36.2

*Note - Silty sand, no data 9-13'

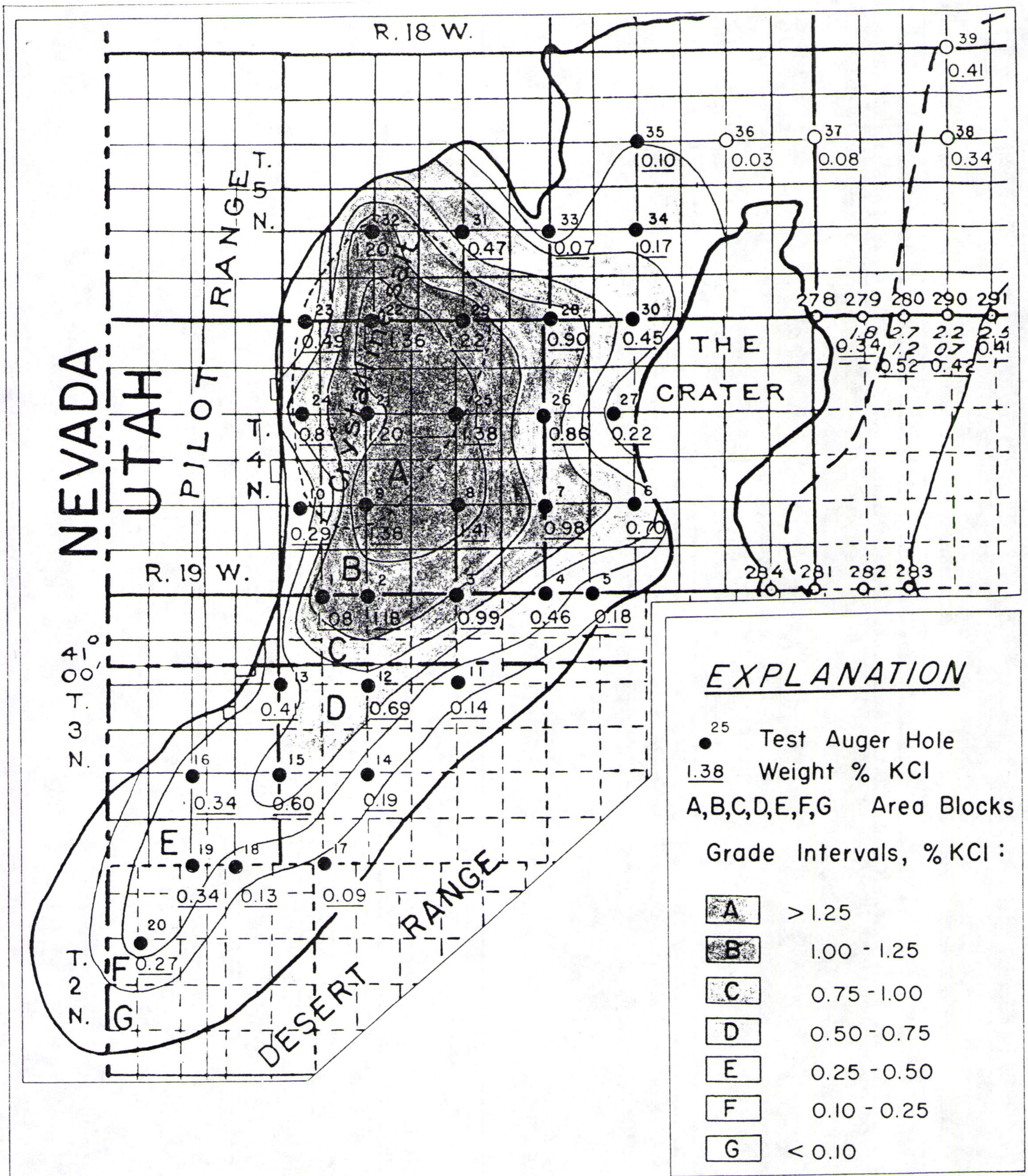

fig 4

NORTHWEST BONNEVILLE AREA

BRINE RESERVES

Polygonal Modified Contour Method

C.A.M

Nov. 1966

8/7/90

CHARTER
SALT LAKE DISTRICT
BONNEVILLE SALT FLATS
TECHNICAL REVIEW COMMITTEE

Bureau of Land Management

1. Official Designation: Salt Lake District Technical Review Committee for the Bonneville Salts Flats study.

2. BLM Objectives and Scope: The Bonneville Salt Flats have been designated as an Area of Critical Environmental Concern with management goals of maintenance and preservation. The results desired of the salt flats study are to identify and quantify the processes causing salt loss and to evaluate specific measures which would reduce salt loss and/or replace the salt lost.

3. Committee Objectives and Scope

Provide technical review and advice to the Bureau of Land Management District Manager regarding the Bonneville Salt Flats study to be conducted by the United States Geological Survey. The committee will function as an oversight group to help maintain the technical integrity, credibility, and objectivity of the salt flats study. Specific duties of the committee are to provide technical review and advice in the following areas 1) reviewing the BSF Study Plan and making recommendations to the District Manager about how the study should be designed and conducted in order to attain the desired results; 2) evaluate study methods to determine their suitability for attaining desired results; 3) periodically reviewing study progress to assure to the extent possible that the study is yielding or will yield desired results; 4) evaluate study results and recommended methods, actions or practices that will mitigate salt loss and/or replace lost salt; and 5) serve as technical experts as needed on behalf of the U.S. Bureau of Land Management and Geological Survey.

4. Period of Time Necessary for the Committee's Activities: Since its functions are related to a specific project scheduled for completion in 1992 the activities of the Committee are expected to be completed by December 1993, but may be extended at the request of the District Manager.

5. Official to Whom the Committee Reports: Salt Lake District Manager, Bureau of Land Management, U.S. Department of Interior.

6. Administrative Support: Administrative support for activities of the Committee will be provided by the Salt Lake

District Office. Support will include taking meeting minutes, copying, paying necessary travel expenses, and other needs.

7. Duties of the Committee: At the request of the District Manager or his designee, the Committee will meet periodically to analyze and comment on the scope, methodologies, and other factors associated with the Salt Flats study plan and ongoing study.

8. Committee's Composition and Qualifications: The Committee's membership shall consist of members with a scientific background, chiefly in the earth sciences including geology, hydrology, engineering and related fields. Other considerations include residence in area, interest, and experience. The committee will comprise 6 to 10 members who are appointed and serve at the pleasure of the District Manager.

9. Member Selection and Service:

a. To be eligible for appointment to the Committee, a person must be qualified through education, training, knowledge, or experience to give informed advice regarding the salt flats hydrological and geological setting and to provide technical review and comment on studies of the salt flats.

b. Vacancies occurring by reason of removal, resignation, or other factors will be filled for the balance of the vacating member's term in the same manner in which the original appointment was made.

c. All members will serve without salary, but will be reimbursed for travel and per diem expenses at current rates for Government employees, should they be required to be in travel status.

10. Subcommittee's: To facilitate the functioning of the Committee, subcommittee's may be formed to study and develop recommendation on selected issues for consideration by the full Committee. Meetings of any Committee or subcommittee shall be called and conducted in accord with federal and Bureau of Land Management regulations and guidelines.

11. Committee Officers: With the exception of the first year the Committee will elect a Chairperson, Vice Chairperson, and secretary/recorder from among its members at the first meeting of each calendar year. The District Manager will appoint the Chair person, Vice Chairperson, and Secretary/Recorder the first year. Chairpersons and members of any subcommittees formed will be appointed by the Committee Chairperson with the concurrence of

the District Manager or his designee.

12. Meetings: Meetings of the Committee will be called by the District Manager, or Chairperson with the concurrence of the District Manager or his designee.

Meetings of subcommittee's will be called by the Committee chairperson/vice chairperson after consultation with the subcommittee chairperson. Meeting notices will be sent to each member and other interested persons which set forth clearly and precisely the issues or topics to be discussed and will provide specific times and places for the meeting. Committee meeting agendas must be reviewed in advance by the District Manager or his designee.

13. Committee Records: Detailed minutes of each meeting, including recommendations made, and copies of all studies and reports received, issued, or approved in conjunction with activities of the Committee and its subcommittee's, will be maintained at the District Office, and with the exception of confidential or proprietary information and USGS interpretive work prior to publication, will be available for public inspection and copying during regular business hours.

The District will be responsible for minutes during District called meetings. The committee will appoint a committee member to take minutes during committee called meetings.
14. Estimated Operating Costs: Activities of the Committee annually will require an estimated $5,000 (including 1/4 work year) of Federal employee support.

14. Meeting Frequency: The Committee will normally meet quarterly, but in no case less than annually. Additional meetings may be called by the District Manager or his designee or Chairperson in connection with special needs.

16. Termination Date: The Committee will terminate four years from the date this charter is approved, unless prior to that date, it is terminated by the District Manager or his designee.

17. Authority: Creation of the Committee is in furtherance of the Secretary of the Interiors's statutory responsibilities for administration of the lands and resources managed by the Bureau of Land Management.

Deane H. Zeller 8/7/90
District Manager Date

8/7/90

3500
(U-027)

JUL 23 1990

Lee Case
District Chief
U.S. Geological Survey
Administration Bldg., Rm. 1016
1745 West 1700 South
Salt Lake City, Utah 84104

Dear Mr. Case,

As follow-up to the meeting on June 12, 1990, regarding the Bonneville Salt Flats Study Plan, the changes listed below are recommended. Overall, these changes were recommended to reduce the cost of study by deleting non-essential components.

Study Element 2. Investigate factors which could cause changes or variations in salt crust density which could include chemistry, dissolved solids, and specific gravity of hard and soft salt. Determine tonnage factor and if swell and/or shrinkage of salt crust is occurring along with causative factors such as changes in water table level.

Ground Control. The BLM will provide ground control for up to 80 wells.

Bench Mark Resurveys. The consensus from the meeting was that the pattern of isostatic rebound would be unlikely to cause uplift of the salt flats and that this would be discussed in the report. It also would be helpful to have the bench marks resurveyed for use as elevation control for the hydrologic study if the cost was reduced considerably. We have met with Don Buhler, Chief of BLM Utah Cadastral Survey who is investigating options and costs for reestablishing the four bench mark elevations used by Lines, 1979.

Study Element 3. Delete. The USGS will discuss potential for wind erosion, but will not attempt to quantify movement by wind.

Study Element 4. Delete.

8/7/90

TRC

Minutes 2/22/90

Attending from BLM: Deane, Jordon, Howard, Don B., Lew, Steve

Video: "The West"/Channel Four Cover Story segments

BLM-SAVE OUR SALT, whatever is harming the salt must go.

ACEC: Area Critical of Environmental Concern

Area of concern-30,000 acres
1% lost salt per year.

progress reports prepared quarterly

Charter

intruprative: reviewed and approved before publicly available-
USGS

Right to 'progress report' to committee including intruprative; right will be removed if abused (released data for other reasons).

**Ultimate Goal: life cycle, behavior, understanding of lost salt, etc. to BSF.

Objectives to committee: help guide study on lost salt and council and provide ideas to BLM.

NEED-typing transportation, etc.-will be provided.

Changes and Comments:

#3. project completion:1992-93, not 1991.

#7. strong hydrology background-Paul and Wallace, Diana can get access if needed.

Per diem provided if necessary.

#10. Can't be recorder and be committee member-BLM will provide minutes if in our office.

#11. If chairperson wants meeting-concurrence with D.O.

strike public and press at meetings-make appropriate information available and also present statement item.

Strike everything involving public in technical.

Don Banks-"Public Affairs Plan"

#12. Add: inturprative confidential data no provided to public.

unknown.

Enter into ARC/information.

Same location, different depths vertical head and chemical.

Attempt to describe tech. factors for good racing-not too detailed.

Racers concerned about quantity and quality of salt.

Raceway surface compared to Pilot Valley-not enough time or money.

Changes in Pilot Valley same as BSF?

Discuss at next meeting.

Spacial and point data stored in same map.

Conduct Geochemical studies

Variable density flow model-best tool to know what's happening.

Flow system analysis
-water level
-hydraulic
-boundary conditions
-transport analysis
-chemistry
-diffusion

Aerial models
-water levels
-chemistry
-rough balances
May not be necessary to use aerial models

Superimpose stress on West Pond.

Quarterly progress reports
-maps
-tables
-data
-published
-water supply paper

Test wells to decide stress on BSF.

Fine scale detailed models-no money or time.

Comparison with Pilot Valley, worth pursuing.

Comments on Plan sent to Deane Zeller by 3/10/90.

8/7/90

MINUTES
OF THE
BONNEVILLE SALT FLATS TECHNICAL REVIEW COMMITTEE MEETING
April 3, 1990, 1:00 p.m.
BLM, Salt Lake District Office

ATTENDING: BLM - Deane H. Zeller, Steve Brooks, Jordon C. Pope, Randy Heuscher; USGS - Joe Gates, Lee Case, Geoff Freethey, Jim Mason, Rob Baskin; Advisory Board - Ton Netelbeek; Bingham Engineering - Stan Plaisier; Independent - Paul Anderson; Utah Salt Flats Racing Association - Hugh N. Coltharp; UGMS - J. Wallace Gwynn; University of Utah - Craig Forster; State of Utah - Dianne R. Nielson

Meeting was called to order by Deane Zeller at 1:10 p.m. One of the purposes of the meeting was enable USGS to define boundary of study and provide a map for Reilly which has not been done. Originally the plan was to follow the Lines study. We now need a line on a map for Reilly and the line must be flexible.

The areas of influence are mostly to the north but there are some to the south that need to be withdrawn from Reilly. USGS proposes to send a map at the end of the week with a line on it for the District to comment.

Reilly will assist but they want an area defined for data collection. Lee gave a list of equipment and data needs to Reilly. Now formally need to know how to get data.

USGS has a proposal ready. Jordon sent an Economy Act Determination to Washington and it has been approved.

Need to discuss (1) comments on the draft version of the Final Study Plan, (2) time and agenda for field trip to Bonneville Salt Flats, and (3) and future actions.

After discussion, Steve stated the date for the tour of the salt flats will be April 19 (Thursday) at 8:00 a.m. Plan to be at Reilly at 10:00 a.m. While at Reilly, you will tour the areas of the ditches, evaporation ponds, mill, and the access on the north side. Bring your own lunch.

Next the comment letters were discussed. Stan stated the comments were incorporated into the Reilly letter. A survey showed several individuals at Reilly were concerned about the rebound in the area and which way the water runs. Lee stated there was stress on the hydrologic systems but the reason for the study was that the salt had decreased.

Stan said that Reilly was concerned that the data was validated and the same methods and procedures to collect the data were used throughout. Want USGS to validate and confirm data at the beginning of the study.

Deane pointed out that the problem at this point is that the Bonneville Salt Flats is diminishing. It is visual and from the data perception. The problem is there is a loss of salt in both a real extent and volume, and we need to know how and where the salt is lost. Don't need to confirm past studies.

Steve said the techniques on how to measure the Bonneville Salt Flats salt loss can be demonstrated on the tour.

Normalized the survey notes that got from UDOT. Study needs to determine cause and effect of what is happening on the salt flats. What part do wind erosion, vehicles, brine-flow have? What are the impacts of the railroad and interstate? Should quantify each factor determined to have an impact. Need to reword the plan to state that BLM needs to protect the salt and find the potential causes of salt reduction.

Paul stated we need a consensus of what the studies are and what the results are.

Steve said in the Turk report, where an air photo evaluation and an on-the-ground measurement were used, they came up with different interpretations. We need to verify the UDOT studies and how accurate was the data measurement.

Deane reminded that the scope was all possible causes that could be relevant.

Lee reminded that we need methodology and need salt thickness from the past at every critical point. Locations are important.

Steve expressed the need to determine the principle and secondary causes of salt loss from the BSF. Need to calculate net volume change on certain areas. Will need to investigate and recommend measures to abate salt loss from the BSF and/or restore salt.

Lee said data on the depth of water will be needed for use in modelling, also need to note surface flow. Need to get with BLM to determine salt loss and get Reilly to buy off on results of analysis.

Stan reminded that need objective study so Reilly doesn't need to do one. USGS is an independent study.

Lee wants to analyze chemical makeup of salt. Geochemical analysis is very time consuming so need details of parameters.

Steve said on Task 5 to locate observation wells that have support from Cadastral Survey to locate well sites and on-the-ground coordinates.

Joe asked if this will take care of the problem of elevations. Are there any benchmarks that can indicate movement?

Lee reminded that on Task 1 to prepare detail plan of study to use data from all relevant sources. Refers to task plan of study and is open to past data before Lines if have it.

Stan asked if data from Reilly will be looked at.

Lee said they would look at all data.

Steve said Task 2 to define the formation and movement of ponds needs concurrence and emphasis. Need to assess the effects of placing the dike along the west side of the ditches on the lands north of I-80 as done by Reilly in 1989.

Lee pointed out that rainfall and wind direction are a big part. Aerial photos help define the movement but they are difficult and costly.

Rob said that satellite imagery of the West Pond indicates that wind moves things around.

In a 15 by 10 mile area surrounding the raceway, 2,400 shots equal one 9 X 9 negative that costs $63,000. 300 shots at high resolution cost $8,000 for one negative.

Steve asked if high altitude negatives have water detail that is needed.

Lee stated that would get qualitative answer with aerial photos on how ponds form and how wind from the northwest (climate) make the ponds move.

Joe reminded that ponds form in the spring and the northwest winds move the ponds from the salt flats to the ditch system.

Steve asked what about the area near the ditches when the water table is lower.

Craig reminded that need to establish if surface ponding is part of the study and if it is significant.

Paul stated that need to know when have ponded water.

Joe said that Lines noted the movement of water to the area of the gradient or the area of the ditches. It is important for if it moves to the east it would be intersected by the ditches.

Lee referred to Task 6 to establish an observation well network and earlier communication on producing descriptions of wells. Need to use Grub Zaner Method to determine what going to look for. Should look at tests, parameters, objectives, well depths, distribution, what to do with discharge, stresses, to get quantitative numbers where areas are and what data exists.

Craig said Task 8 to conduct and analyze aquifer tests that evaluate aquifer test need and if should do them considering available money. Make strategy for testing in next phase and if have to be done.

Steve said Task 9 to assess raceway surface/salt that monitoring would be sufficient. Need to note if there are changes in density of salt crust. If density changes, then measurement could be invalid.

Hugh discussed the best years for racing on the salt, the buckling of the salt, and the dampness/dryness of the salt for racing. Stated that need to focus on salt loss vs surface use. Need soil moisture measurement of salt with a weather station.

Deane noted that the plating and buckling of the salt is a recent phenomenon. Asked if there is any scientific information.

Lee said they can make a structural analysis of the salt considering factors such as moisture content, saturated/unsaturated zone, and wind.

Paul recommended Pilot Valley if consider a control area for Task 9.

Lee stated that need to know what salt is like.

Craig recommended that make neutr~~al~~on probe on periodic basis of soil moisture and quantification.

Howard stated that for a permanent monitoring site on the BSF, location is important.

Lee referred to Task 12 to design and construct transport model. Stated that would follow suggestions.

Craig suggested 3-D model based on seasonal and ditch influences and effects. Have a goal of a shallow system vs a deep system.

Lee noted that the water table fluctuates and what is the concept of deep and what are the effects at a shallower zone. Need to show what is happening in saturated zone. Have variable density flow model available. Model is strictly saturated flow model.

Craig said to consider a saturated/unsaturated flow model to keep open.

Steve asked if fracture system/impermeable muds will cause a problem?

Lee stated fracture flow is too extensive. System can act as porous medium when system is full of fractures.

Paul asked if fractures are perennials.

Deane referred to the charter.

Joe stated that any timetable for the existence of the committee should be left open.

Deane said that to correlate life of committee to life of study can be indefinite. Need to separate objectives of committee from objectives of study. Committee needs to address results and study and use them as a tool.

Steve stated committee's work is to verify scientific aspects of remedial ideas and engineering solutions.

Hugh reminded that USGS is to make study and recommendations.

Deane pointed out that need a wide array of alternatives on BSF so study doesn't need to be extended for 5 years. Need to do it on time.

Craig reminded that need to state factors that can change.

Stan said that want to form solutions and base them on data that is found.

Steve pointed out that mitigation should address the problem to slow down the salt loss.

Ton stated that when refer to mitigation methods on salt loss need to evaluate methods as a committee not an engineering group so cannot make recommendations of specific measures.

Steve informed the committee that need to amend charter to reflect scope of proposal study.

Lee stated that USGS will assess data to see if it is applicable.

Paul reminded that during tour will verify salt loss, and identify and quantify processes causing salt loss.

Lee stated that on #2 that insert new section having the first section as the BLM objectives and the second section as the committee's objectives.

Deane stated need to elect chairman of committee. Committee decided to postpone action on designation of chair or vice chair until next meeting.

Will send out letter to notify of next meeting.

Lee said committee will meet in a couple months for the factual version of the working proposal of the plan of study. Stated that need to meet on mitigating measure before final plan of study.

Deane adjourned the meeting at 4:20 p.m.